Sulzer Chemtech AG, CH-8404 Winterthur, Switzerland

Static mixer with precision cast elements

The invention relates to a static mixer with precision cast elements in accordance with the preamble of claim 1, to a cast element for a mixer of this kind, and to a method for manufacturing the mixer as well as to uses.

A static mixer by means of which highly viscous polymer melts can be homogenized is known from EP-A 0 646 408. This mixer can be used as a mixer head in the nozzle of an injection molding machine or as a melt mixer following the helix of an extruder. It is assembled from cast elements and intermediate elements and has a cylindrical shape. The cast elements contain structures, for example grid structures, which effect a mixing process in a through-flowing melt. The structures which are shown in EP-A 0 646 408 are built up of layers which contain passages and which are oriented parallel to a central axis. In a preferred embodiment the intermediate elements together with parts of the cast elements, namely with flange-like reinforcing rings, form a tubular jacket, within which a plurality of mixer structures are arranged one behind the other. In adjacent mixer structures the layers are in each case displaced with respect to one another by a predetermined angle, preferably by 90°. In order that this displacement is reliably produced in the assembly of the static mixer, cams are molded on the reinforcing rings and cut-outs are provided at the intermediate elements in a manner which is complementary to the cams. In a correct assembly the

cams fit into the corresponding cut-outs and thus provide for a predetermined orientation of the elements.

The cast elements can be manufactured by means of precision casting to within tolerances of 0.1 mm. For use in injection molding machines this tolerance is insufficient. Because of the sealing, a total length of the static mixer which is to be strictly observed is required in machines of this kind.

The object of the invention is to further develop the static mixer of the named embodiment in such a manner that a predetermined total length of the mixer, such as for example is required in injection molding machines, can be manufactured precisely. This object is satisfied by the static mixer which is characterized in claim 1.

The static mixer contains precision cast elements which are arranged along a central axis and which in each case have a reinforcement region at their circumference which extends over the entire circumference. These cast elements are assembled with intermediate elements to form a cylindrical body. Joint locations between the elements form surfaces which stand transversely to the central axis. For each isolated cast element, in a rotation about its central axis, the joint locations are accessible to machining tools for subsequent machining — in particular for grinding or turning. As a result of the subsequent machining a predetermined total length of the mixer in the direction of the central axis can be precisely achieved.

In the known cast elements a required subsequent machining is made

impossible due to the cams at the reinforcing rings. In the intermediate elements a subsequent machining is not required since the latter can be brought into a predetermined shape from a tube by a cutting method, with it being possible to produce the required precision.

Subordinate claims 2 to 4 relate to advantageous embodiments of the mixer in accordance with the invention. The cast element of this mixer is the respective subject of claims 5 to 8. Claim 9 relates to a method for manufacturing the mixer in accordance with the invention and claim 10 relates to uses of the mixer.

The invention will be explained in the following with reference to the drawings. Shown are:

Fig. 1 a first embodiment of the cast element in accordance with the invention having a reinforcing ring,

Fig. 2 an end of an intermediate element fitting with the cast element of Fig. 1,

Fig. 3 a developed projection of the circumference of said reinforcing ring and a corresponding developed projection of the intermediate element,

Fig. 4 an oblique view which illustrates a part of a mixer in accordance with the invention,

Fig. 5 a longitudinal section through a nozzle which contains a mixer head,

Fig. 6 a perspective illustration of the end region of the first embodiment of the mixer in accordance with the invention,

Figs. 7, 8 developed projections as in Fig. 3 of a second and of a third embodiment, respectively, and

Figs. 9, 10 developed projections of the reinforcing rings of two further embodiments.

A cast element 1 in accordance with Fig. 1 can be manufactured through a precision casting in which a casting mold is formed by means of a wax body, the application of a ceramic jacket onto the wax body, subsequent removal of the wax and a firing of the ceramic jacket. By this casting method, a tolerance of about 0.1 mm results for the attainable accuracy of fit. Usually, the cast element 1 is cast from a metallic alloy. With other casting methods casting elements 1 can also be manufactured of ceramic material or plastic. A gridwork 3 — namely the mixer structure 3 — and a reinforcing ring 4 form the cast element 1 in the form of a monolithic body. The gridwork 3 is assembled from webs 31 which are arranged in layers 32. The layers 32 are oriented parallel to a central axis 10. The webs 31 of adjacent layers 32 cross one another and enclose a uniform angle of 45° with respect to the direction of the central axis 10. This angle can also have a value between 10 and 70°. The flange-like ring 4 is a reinforcement region which extends over the entire circumference of the cast element 1.

The static mixer is assembled from a plurality of cast elements 1 and intermediate elements 2, see Fig. 2, which are arranged along the central axis 10 and which thus form a cylindrical body. The mixer structures 3 are formed in such a manner that in the assembled mixer the ends 30a and 30b of adjacent cast elements 1 do not make contact. The elements 1 and 2 are in contact at joint locations which are formed by ring-shaped surfaces 40a, 40b of the reinforcing ring 4 and ring-shaped surfaces 20a, 20b (see Fig. 3) of the intermediate elements 2. These surfaces 40a, 40b and 20a, 20b form the only joint locations. In Fig. 3 a developed projection of the circumference of the reinforcing ring 4 and a corresponding developed projection of the intermediate element 2 are illustrated. Arrows 420 indicate how the ring 4 can be placed onto the intermediate element 2. The lateral lines 400 and 400' and, respectively, 200 and 200' are intersection lines, at which in each case the circumference is enclosed (angles 0° and 360°).

The reinforcing ring 4 has at the surface 40a segment-like cut-outs 41, 41' and at the surface 40b similarly shaped cut-outs 42, 42' which are complementary to projections 21, 21' and 22, 22' respectively of the intermediate element 2. The cut-outs 41, 41', 42, 42' form two pairs, wherein the cut-outs of the pairs 41, 41' and, respectively, 42, 42' in each case are arranged diametrically opposite to one another and wherein the two pairs are offset with respect to one another by 90°. The corresponding projections 21, 21', 22, 22' of the intermediate element 2 are arranged in such a manner that in each case two of the projections 21 and 22 and, respectively, 21' and 22' are aligned one after the other in the direction of the central axis 10. Through these arrangements an

offset of the grid structures 3 between two adjacent cast elements 1 by 90° results.

The oblique view of Fig. 4 shows a part of a mixer in accordance with the invention. The mixer structure 3 is indicated by two mutually crossing diameters. The cast elements 1 and intermediate elements 2 can be held together by a longitudinally slit cylinder 5 (slit 50) of a resiliently elastic sheet metal lamina.

The joint locations between the elements 1 and 2 are transverse to the central axis 10. The joint locations which are given by surfaces 40a, 40b of the cast element 1 are accessible to machining tools for a subsequent machining when the isolated cast element is rotated about its central axis 10. It can be subsequently machined by grinding or turning. As a result of the subsequent machining a predetermined total length L of the mixer in the direction of the central axis 10 can be precisely achieved, so that the mixer for example fits exactly into a nozzle 6, as illustrated in Fig. 5. The mixer is inserted sealingly in a cavity 60 of a nozzle capsule 61 while being pressed by a component 62.

At its ends the mixer has suitably modified end pieces 2' instead of intermediate elements 2. Fig. 6 illustrates in a perspective illustration the mixer end region with the end piece 2'.

Further possibilities for realizing the mixer in accordance with the invention are conceivable in addition to the above described first embodiment. Some of the above parts of the intermediate elements 2 can be separate parts which are fitted into cut-outs of the intermediate

element 2. One example is shown in Fig. 7. Cut-outs 43 and 44 in the reinforcing ring 4 are formed as circular blind holes. Corresponding projections 23 of the intermediate element 2 are cylindrical bolts 23, which are fitted into cut-outs. Furthermore, only one bolt 23 with corresponding cut-outs 25 and 44 or 43 can be provided in each case per joint location.

In the exemplary embodiment shown in Fig. 8 the reinforcement region 4 is a ring which is extended by two webs 45 which cross the ring 4. The reinforcement region 4 has all over the same thickness, which is also provided for two wall pieces 26 of the intermediate element 2. These wall pieces 26 fill the gaps between the webs 45, with a certain clearance being provided. At the same time they form a toothing between adjacent cast elements 1. The wall pieces 26 are connected to one another via a sheet metal lamina ring 27 and thus form the intermediate element 2. The positions of the two ends 30a and 30b of the mixer structure 3 are indicated by the chain-dotted lines 30a' and 30b'. In the assembled mixer the surfaces 40a' and 40b' form a joint location between adjacent cast elements 1. There are no length-determining joint locations between the cast elements 1 and the intermediate elements 2. In this exemplary embodiment the angular displacement of adjacent mixer structures 3 is not produced by the reinforcement 4. Therefore, two different cast elements 1 must be provided which differ by a different orientation of the mixer structures 3 relative to the arrangement of the webs 45.

In the exemplary embodiment in accordance with Fig. 9 the

intermediate element 2 (not illustrated) is formed similarly as in the first exemplary embodiment. Joint locations are again formed by surfaces 40a' and 40b' of the reinforcement region 4 and corresponding surfaces of the intermediate element 2.

In the exemplary embodiment of Fig. 10 the reinforcement region 4 is again formed in the shape of a ring, and cut-outs are formed by trapezoidal grooves 48.